Tamala Limestone — a significant resource for the Australian building block industry

by J. M. Fetherston

Abstract

Western Australia was settled in the Swan River Colony in 1829, later to become the City of Perth. The extensive resource of high-grade Pleistocene Tamala Limestone was soon discovered along the coastline and at Rottnest Island and became the first stone to be used extensively in early buildings of the colony. Tamala Limestone and equivalent units extend in places along the coastline from Shark Bay south to Cape Leeuwin and eastwards to Esperance, and consist mainly of a fine- to coarse-grained, cream to pale-brown eolian calcarenite. The State's building-block extraction industry extends from Geraldton in the north to the Perth Metropolitan area and south towards Bunbury.

Natural limestone blocks are quarried only in the Carabooda–Nowergup and Moore River areas to the north of Perth, since these areas contain a higher strength limestone with calcium carbonate contents often in excess of 85%. Lower grade limestone (48–78% calcium carbonate) is crushed for the manufacture of reconstituted limestone blocks and other products. Some natural limestone block manufacturers also produce reconstituted block products as a byproduct from low-grade and waste materials, while in all other areas, reconstituted blocks and pavers are produced as a substitute product for natural limestone blocks. Soft calcarenite requires special quarrying techniques for extraction in block form. Block processing is divided into two parts. The first of these is the quarry-cut block extraction process over a level site where rough-sawn building blocks are cut to final size and packed for sale on site in the quarry. In the second added-value stage, quarry-cut blocks are removed to a processing plant for fine sawing and machining into a variety of diamond-cut bricks, cladding, pavers, pier blocks, and special profile products.

In recent years, the Western Australian industry has become the largest producer of cut limestone blocks in Australia. Estimates for 2003–04 show the State produced almost 234 000 tonnes valued at approximately $4.5 million. Estimated production figures for reconstituted limestone products were in the order of 237 000 tonnes valued at about $3.08 million. In 2004, Austrade identified niche market opportunities for Australian dimension stone mainly in the Indo-Pacific region, particularly New Zealand. In 2006, the Tamala Limestone natural stone-block industry maintains its position as Australia's largest producer of high-quality, cut limestone blocks, backed up by the production of a substantial quantity of reconstituted limestone blocks, bricks and other products. Over recent years, the industry has expanded in line with increased sales both in Western Australia and the eastern states. In addition, exports to New Zealand, Malaysia and other countries in the Indo-Pacific region have continued to increase.

KEYWORDS: Western Australia, Perth Basin, dimension stone, building stones, limestone, history, mineral exploration, quarrying, natural resources, mineral economics.

Introduction

In 1829, Western Australia was settled in the Swan River Colony that was later to become the City of Perth. The early settlers soon discovered the extensive resource of high-grade Pleistocene Tamala Limestone located in places along the coastline, mainly from Scarborough southwards to Coogee. Another large limestone resource was also located on Rottnest Island, about 20 km offshore from Fremantle. This coarse- to medium-grained, sandy limestone, more correctly referred to as 'calcarenite', was found to be relatively soft and easily workable. Accordingly, Tamala Limestone became the first stone to be used extensively in early buildings of the colony. Over time, quarries were established at Fremantle, Rottnest Island, Cottesloe, Mosman Park, Coogee, and Reabold Hill in the City Beach area.

In 1831, Western Australia's oldest public building, the Round House, was built at Arthur Head in Fremantle to be used as a gaol and detention centre. Building continued in Perth, Fremantle and Rottnest Island using Tamala Limestone in the construction of splendid colonial and early 20th century buildings for the next 100 years. These included the Fremantle Boys' School (1854), the Main Lighthouse on Rottnest Island (1896), and the Perth Mint (1899). In 1932, Winthrop Hall at the University of Western Australia, the last of Perth's grand dimension-stone buildings of the era, was completed. Built in the style of an Italian medieval guildhall, the walls and belltower of this magnificent building are of high-grade, cream-coloured Tamala Limestone blocks quarried from the university's own quarry at Coogee (Fig. 1).

The onset of World War II heralded a period of comparative inactivity in the building stone industry that persisted for almost 50 years. In the 1980s, dimension stone was rediscovered by architects as a building material of choice and they began cladding large buildings both inside and out with pre-cut stone slabs. Since that time, limestone blocks have once again found numerous applications in home and office construction, as well as in streetscape and landscape design.

A full description of the limestone block industry in Western Australia is discussed in Fetherston (in prep.). This includes the location of deposits, chemical analyses and petrological sample descriptions, quarrying and processing, as well as product applications for natural-cut limestone blocks and reconstituted limestone products. In addition, an overview of the dimension stone industry in Western Australia, including reference to the Tamala Limestone block industry, is given in Fetherston (2004).

Location of Tamala Limestone resources

In Western Australia, the Pleistocene Tamala Limestone and equivalent units extend, in places, in parallel and close proximity to the modern coastline from Shark Bay on the central-west coast southwards to Cape Leeuwin, and eastwards to Esperance along the south coast. This limestone unit consists mainly of a fine- to coarse-grained, cream to pale-brown eolian calcarenite.

The State's limestone building-block extraction industry is located at sites extending from Geraldton in the north, to the Perth Metropolitan area, and southwards towards Bunbury. Currently, the only areas where natural limestone blocks are quarried from high-grade limestone are in the Carabooda–Nowergup area on the northern fringes of the Perth Metropolitan area and at Moore River in the Guilderton area about 80 km north-northwest of Perth (Fig. 2).

Nowergup, where six quarrying operations are currently in progress (Meteor Stone, Italia Limestone, Limestone Building Blocks, Limestone Natural, Limestone Resources Australia, and Crown Limestone Supply), is currently the principal area of activity for natural limestone building blocks. At

Figure 1. Historic Tamala Limestone buildings in Fremantle and Perth: a) the Round House in Fremantle is Western Australia's oldest public building (1831); b) Fremantle Boy's School (1854); c) the Perth Mint (1899) constructed from limestone blocks quarried on Rottnest Island; d) Winthrop Hall at the University of Western Australia (1932). Limestone blocks for the walls and belltower were sourced from the university's own quarry at Coogee

Carabooda, there is one block quarry in operation (Limestone Resources Australia), and at Moore River, Limestone Resources Australia is quarrying blocks from two adjacent mining leases. In general, it appears that the overall strength of the calcarenite limestone is governed by the stone's physical properties of compressive and flexural strength that are often be related to a high calcium carbonate ($CaCO_3$) content in excess of 85% for high-grade building block material (Abeysinghe, 1998).

In other extractive areas, the limestone is mostly too soft for cutting natural stone blocks. In general, this is attributed to the lower strength limestone present in these areas, where the calcium carbonate ($CaCO_3$) content ranges between a high of 78% and a minimum of 48%. In these areas, lower grade limestone is crushed and used for the manufacture of reconstituted limestone blocks, pavers, and other products. This situation is present at Carabooda, where Limestone Building Blocks manufacture reconstituted limestone blocks as a substitute industry. Other similar areas include the Yanchep area north of Perth (Archistone), Hope Valley north of Kwinana (Stoneridge Quarries W. A.), Narngulu southeast of Geraldton (Amazzini and Son), and a number of private operations at Myalup and Kooallup north of Bunbury (Fig. 2).

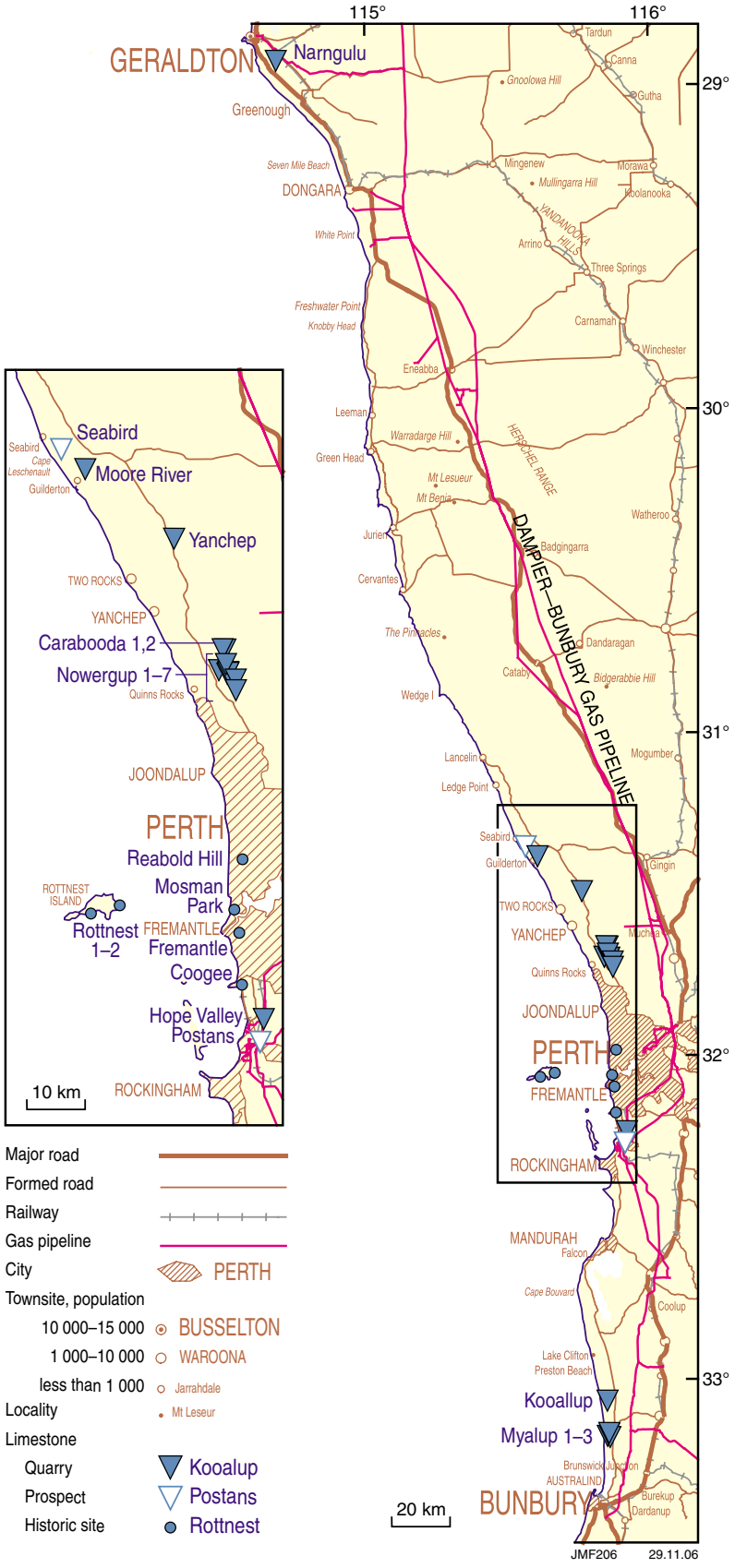

Figure 2. Location of Tamala Limestone dimension stone quarries, prospects, and historic sites

Calcarenite block quarrying and processing techniques

Soft calcarenite limestones require special quarrying techniques for their extraction in block form. Before operations commence, a smooth and level site must be prepared over extractable stone. Calcarenite block processing is divided into two parts. The first of these is the quarry-cut block extraction process, where rough-sawn building blocks are cut to final size and packed for sale on site in the quarry. The second added-value stage requires the removal of a proportion of the newly produced quarry-cut blocks to a processing plant for fine sawing and machining into a variety of diamond-cut bricks, cladding, pavers, pier blocks, and special profile products.

Quarry-cut block extraction

In the first stage of the block extraction process, large areas of the quarry floor are sawn with a series of parallel, vertical cuts up to 350 mm deep, using a rail-mounted, electric-powered sawing machine fitted with a tungsten-tipped saw blade. The parallel cuts are spaced to produce blocks in a variety of sizes. In the second stage, the cutting machine travels at right angles to the original quarry-floor cut lines. Block cutting is achieved by using the rail-mounted machine fitted with several tungsten-tipped saws designed for making simultaneous vertical and horizontal cuts. During these passes, the machine is adjusted to cutting different widths and heights to produce quarry-cut blocks in a variety of standard sizes (Fig. 3).

Quarry-cut blocks, ranging in size from 1000 × 350 × 350 mm to 500 × 117 × 105 mm, are removed from the cutting operation in an excavator bucket and stacked onto pallets on the quarry floor. Once packing is complete, the blocks are ready for dispatch to clients requiring a more natural-textured surface. The finished blocks have a slightly roughened, quarry-cut texture reminiscent of early colonial cut stone. They are produced specifically for use as housing bricks, and blocks for landscaping and retaining walls (Fig. 4).

Added-value processing

The second part of the operation is the diamond-cut block process where quarry blocks are removed to a sawing plant for added-value processing using diamond saws and other machinery to produce a vast array of bricks, blocks, wall cladding, pavers, and special profile products.

Bricks

According to customer requirements, quarry-cut blocks delivered to the cutting plant are progressively reduced in size by cutting with diamond-tipped saws to produce more highly finished blocks and bricks with much smoother surfaces and increased dimensional accuracy. In the plant, quarry blocks are diamond sawn in the first instance to produce quarry-face housing bricks in which the visible face and perps (vertical ends) are left in their natural state. The bricks may then have their quarry-cut faces smooth sawn with perps remaining, and finally, may be diamond-cut on all surfaces. Finished products range from 330 to 500 mm in length, 100 to 165 mm in thickness, and are produced in a variety of heights from 76 to 332 mm.

Cladding, pavers, and pier blocks

Other mass-produced limestone products that only requiring diamond sawing include cladding, pavers, and pier blocks. While most styles are diamond cut on all sides for improved visual appearance and dimensional accuracy, a few designs retain quarry-cut edges and perps. Cladding slabs are 30 to 35 mm in thickness and are produced mainly as rectangular panels with their longest sides between 300 and 500 mm (Fig. 4).

Paver blocks have a standard thickness of 60 mm and are square or rectangular in outline with their longest sides between 300 and 500 mm. Pier blocks are cut as rectangular prisms in about six sizes up to a maximum size with a face measuring 400 × 332 mm and a thickness of 195 mm.

Figure 3. Extractive process for Tamala Limestone building blocks: a) the level limestone floor is cut with a series of parallel saw cuts to produce blocks in a variety of standard sizes; b) rail-mounted, multi-blade quarry saw cutting standard size blocks; c) quarry saw blade fitted with tungsten carbide cutting teeth; d) quarry-cut blocks packed on site for dispatch to clients (photo (d) courtesy Meteor Stone)

Special profile products

A number of special profile products are produced for the building and landscaping industries. All these products require special diamond cutting and many require special curved profiles to be added to complete the design. Curved profiles are accomplished using a milling machine fitted with a variety of diamond-faced grinding or specially shaped profiling wheels designed to cut the required curvature in stone edges.

Special products include pier caps for fixing to the top of limestone piers, ornamental copings for fitting to the top of walls, corbels for wall ornamentation, and bullnoses and sills for fitting around doors, windows, and other ornamental features. Many designs require a combination of diamond cuts and curved profiles to complete while others only require

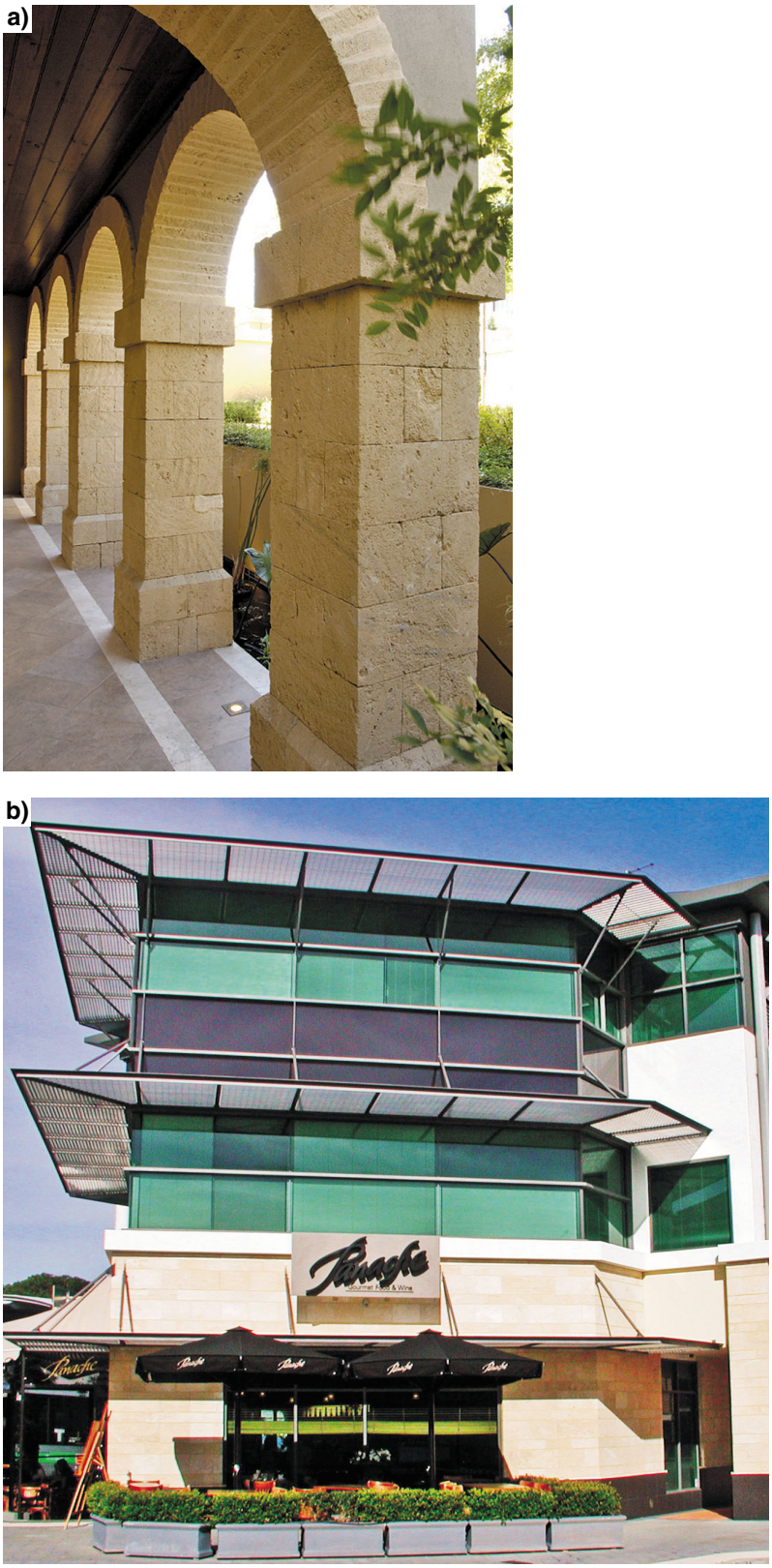

Figure 4. Applications for Tamala Limestone natural stone blocks: a) biscuit-coloured quarry blocks from Moore River used in archways and as column cladding in a contemporary Italian-style villa in Melbourne; b) diamond-cut, cream-coloured slabs from Nowergup used to clad a modern office building in Perth; (photo (a) courtesy Limestone Resources Australia, © Discovering Stone, 2006; photo (b) courtesy Meteor Stone)

additional cutting. Most products are produced in lengths or square sides ranging from 300 to 500 mm. Some sills have lengths up to 1000 mm.

Corner returns are right-angled blocks designed to wrap around wall ends for a more complete finish. These special blocks only require multiple diamond cuts to complete and range from 150 to 490 mm on the longest side.

A number of other limestone products also require added-value processing for completion, including diamond sawing, profiling, and other processes. These include ornamental pedestals and plinths between 420 to 1030 mm in height, table legs, and garden edging, as well as ornate fireplace surrounds including mantelpieces and hearths.

Byproducts and substitutes

Byproducts

In a number of Tamala Limestone block quarries, minor zones of weathering have developed in areas of groundwater movement where some or all of the calcium carbonate binder within the limestone has been dissolved and removed from the rock. This weathering process generally renders the limestone too soft for block cutting, resulting in its removal as waste material. Rather than dumping the limestone waste into landfill areas, it is retained and combined with other limestone waste products such as large quantities of limestone grit, offcuts from sawing operations, and other reject material.

These waste materials form the basis of the reconstituted limestone byproduct industry that is carried out as a secondary process by many of the limestone block producers in the Carabooda–Nowergup area north of Perth. Producers in this area estimate that generally about 40% of total limestone production goes into the manufacture of reconstituted limestone blocks. In areas where weathering is more extensive, this estimate may be higher, possibly reaching 60% in a few places. The reconstituted block-making process is described below.

Substitutes

In a number of areas on the Swan Coastal Plain, at Carabooda, Yanchep, Hope Valley, Narngulu near Geraldton, and Myalup and Kooallup north of Bunbury, the Tamala Limestone is quarried as a weathered, friable calcarenite. This material is crushed and processed for the manufacture of reconstituted limestone building blocks and pavers as substitutes for natural limestone blocks.

There are two methods employed in the manufacture of reconstituted limestone products. Firstly, in both the substitute and limestone byproduct industries, the weathered limestone is crushed to a coarse powder. It is then mixed with water and cement in a predetermined ratio. Coloured oxides for tinting may also be added. The mixture is added to a batching machine that applies considerable pressure to compress the material into block-sized moulds. The newly formed blocks are produced in various sizes and profiles, with the largest size being 1000 × 350 × 350 mm. These are deposited in batches as the machine progresses across a concrete pad on the quarry floor, forming lines of finished product (Fig. 5a).

In addition to the batching process, the second method adopted by Archistone at its Yanchep processing plant is the manufacture of pavers by wet casting in rubber moulds. In this process, a wet mixture of crushed limestone and cement is poured into rubber moulds. Other additives to the mixture may include aggregate for added strength, coloured oxides for standardized tinting, and a moisture dispersant to reduce the effects of efflorescence. The moulds are designed to produce pavers in various standard sizes and surface textures. On drying, the pavers are turned out of the moulds and stockpiled for curing. In a third stage, special orders may be hand finished with profiling treatments such as bullnosing (Fig. 5b).

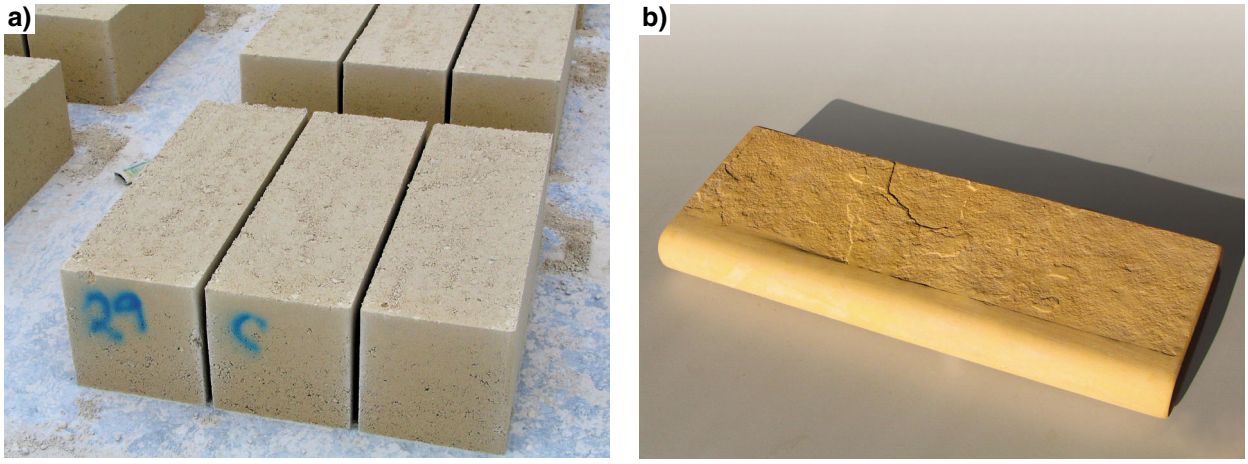

Figure 5. Reconstituted limestone blocks: a) batch-produced blocks 1 m in length; b) an example of a colour-tinted bullnosed paver, 40 cm in length, produced by wet casting (photo (b) courtesy Archistone)

In this industry, reconstituted limestone products are produced to simulate most blocks, pavers, and special application items such pier caps, copings, and bullnoses produced by the natural limestone block industry. Reconstituted limestone products have several advantages over natural limestone. In the first instance, they are inherently stronger due to their vastly increased density (up to 60%) caused by a substantial reduction of pore space. As well, body strength is increased by the addition of aggregate to the mixture. This material may also be tinted by natural oxides to produce products in about ten different standardized colours. It appears the main disadvantage of reconstituted limestone is that it is extremely difficult to reproduce the appearance and feel of surface textures present in natural limestone.

Current trends in the limestone block industry

In recent years, the limestone block industry has increased production to the point where the State has become the largest producer of cut limestone blocks in Australia. Estimates for 2003–04 show that Western Australia produced almost 234 000 tonnes valued at approximately $4.5 million. In addition, estimated production figures for reconstituted limestone blocks, bricks, and pavers were in the order of 237 000 tonnes valued at approximately $3.08 million. This figure, when combined with the figures for natural limestone block production, yields a total production for the limestone building block industry in excess of 471 000 tonnes, with an estimated total value of production in the order of $7.65 million for that year.

In 2004, Austrade identified niche market opportunities for Australian dimension stone mainly in the Indo-Pacific region, particularly in New Zealand where Australia may have a competitive advantage in their steadily growing building industry due to our close proximity and lower transportation costs. This is borne out by the export figures for 2004 for limestone quarry blocks and diamond-cut blocks and slabs where Australia's main overseas markets were New Zealand (95%) and Fiji/French Polynesia (5%; Keating, 2005).

Summary

In 2006, the Tamala Limestone natural stone block industry continues to maintain its position as the largest producer of high-quality cut limestone blocks in Australia. It also continues to produce a substantial quantity of reconstituted limestone blocks, bricks, and other products. In recent years, the industry has expanded in line with increased sales both within Western Australia and also to the eastern states due to rapid growth in the building industry. In addition, exports to New Zealand, Malaysia, and other countries in the Indo-Pacific region have continued to increase in recent years.

It is important that this significant industry be allowed to maintain or increase production in future years, particularly when current sites become worked out. Past investigations indicate that there are probably adequate resources of high-grade limestone situated in places along the coastal corridor between Perth and Dongara. To prevent disruption to production and current markets it is vital that companies to be permitted to access land in these areas, which contain adequate resources of high-grade limestone, for use as future quarry sites.

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